US Army Medical Research and Materiel Command (MRMC)

Blast Injury Research Planning Meeting

Frederick, Maryland

10 July 2006

PROCEEDINGS

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Preface

It is my pleasure to acknowledge the work of the Military Operational Medicine Research Program staff in spearheading this effort. Their planning, organization and implementation of this meeting was critical in moving this initiative forward in anticipation of the release of the Department of Defense Directive on Blast Injuries. These Proceedings will serve as the foundation for the future direction of the DoD blast injury research program.

I wish to commend the meeting presenters and panel members for their excellent contributions both in their presentations and discussions. Without their cooperation and collaboration, this report could not have been accomplished. I thank all of the investigators for their incredible work in this field of research as they provide the evidence for preventing, mitigating and treating blast injuries.

The purpose of this report is to delineate the future directions of blast injury research by identifying where critical knowledge gaps exist and by creating a synergy in research efforts to exponentially move this field forward. It is our imperative in serving the Warfighter. Thank you for *leaning forward* to accomplish this critically important mission.

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Principal Assistant for Research and Technology
U.S. Army Medical Research and Materiel Command

MRMC Blast Injury Research Planning Meeting
PROCEEDINGS

EXECUTIVE SUMMARY

13 July 2006

MRMC BLAST INJURY RESEARCH PLANNING MEETING. MRMC held a blast injury research planning meeting on 10 Jul 2006 under the new Department of Defense (DoD) program on "Medical Research for Prevention, Mitigation and Treatment of Blast Injuries." The DoD Directive 6025.21E establishing this medical research program was effective 5 Jul 2006 and designated the SECARMY as the DoD Executive Agent (EA). The planning meeting was to summarize the state of the science for blast injury. Investigators and panel members from key organizations were convened, including DDR&E, OASD (HA), TSWG, MRMC, RDECOM, AFRL, JIEDDO, DARPA, OTSG, ONR, DTRA, and USUHS. Investigators working in this field presented what research has been done, what is currently being done, and what is currently funded. Panel members and investigators identified critical knowledge gaps and funding priorities. In closed deliberations, the panel recommended expenditure of remaining FY06 blast injury research funds to support the Joint Trauma Analysis Program. Panelists also proposed a two-tiered EA management strategy, a Steering Committee, and a Flag-level Executive Advisory Board. The MRMC Commanding General approved the recommendations on 12 Jul 06.

(UNCLASSIFIED)

MRMC Blast Injury Research Planning Meeting Proceedings
10 July 2006

INTRODUCTION

The US Army Medical Research and Materiel Command (MRMC) sponsored a Department of Defense (DoD) Blast Injury Research Planning Meeting in Frederick, Maryland on 10 July 2006. The objective of the meeting was to map out gaps in the current and planned DoD investment in blast injury research.

The MRMC organized this meeting under a new DoD medical research program established by Department of Defense Directive (DoDD) 6025.21E – "Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries," dated 5 Jul 2006. This DoDD implements Section 256 of Public Law 109-163, "National Defense Authorization Act for Fiscal Year 2006," and it assigns the Secretary of the Army as the Program's Executive Agent (EA). Within the Army, research program management is expected to be executed through the MRMC.

The meeting was attended by presenters, panel members, and invited observers. Meeting participants included representatives from all medical and non-medical organizations known to have an investment in research, development, test, and evaluation (RDTE) programs relevant to blast injury prevention, mitigation, and treatment. The meeting format consisted of a series of presentations on past, current, and future blast injury research programs; an open discussion of blast injury knowledge gaps; and a closed discussion among the panel members to develop a list of medical research priorities to close the gaps and to develop a proposed strategy for the future management and coordination of the program.

The appendix to these proceedings contains several documents, including the agenda, a one-page summary of each presentation, and lists of the participants.

METHOD

Crosswalk between DoDD 6025.21E and Structure of Discussions

DoDD 6025.21E is focused on coordinating and managing medical research efforts and DoD programs related to the prevention, mitigation, and treatment of blast injuries. Enclosure 2 of the DoDD includes taxonomy of injuries from explosive devices. The taxonomy's injury categories are primary (injuries caused by blast overpressure), secondary (injuries caused by fragments), tertiary (injuries caused by displacement of the body or body parts), quaternary (injuries caused by explosive products such as heat and toxic gases), and quinary (injuries caused by post-detonation environmental contaminants, including bacteria and radiation). Participants agreed to focus their discussions on primary blast injuries because they felt that the other injury categories are being adequately addressed under mature programs.

Framework for Blast Injury Knowledge Gaps

Participants discussed knowledge gaps within the framework of the following four gap categories: Protection, Diagnostics, Treatment, and Rehabilitation. Injury prevention and mitigation were discussed in the context of the Protection category. Treatment was viewed as both acute, and rehabilitative. The taxonomy of injuries from explosive devices in Enclosure 2 of the DoDD was not used. Rather, the participants structured their discussions around the body systems such as pulmonary, gastrointestinal (GI), extremities, and craniofacial.

Status of Current Research

A prime objective of the meeting was to summarize the state of the science for blast injury research. Each of the speakers provided a brief presentation followed by a question and answer session. Some of the speakers provided a summary their presentations, see Appendix G.

Development of Blast Injury Knowledge Gaps

The participants identified knowledge gaps during the question and answer periods that followed the individual presentations and during the open discussion period. After the presentations, an open discussion was held with the presenters, panel members, and observers. Flipcharts were used to facilitate the discussion, which was organized around the four gap categories of Protection, Diagnostics, Treatment, and Rehabilitation. Within the four areas, gaps were delineated according to body systems such as pulmonary, GI, extremities, and craniofacial.

Development of Medical Research Priorities

During the closed session, the panel reviewed the blast injury knowledge gaps identified during the open session and developed a list of research priorities to fill the gaps. The panel used a modified version of the four gap categories to organize their recommended research priorities. The categories they used were Protection (Secondary Prevention), Diagnostics, Acute Treatment, and Return to Duty/“Reset.” The fourth category, Return to Duty/“Reset,” reflected the panel's view that research needs to be focused on preparing the injured soldier to return home from the battlefield and, in the longer term, to return to society as a healthy individual.

FINDINGS

Blast Injury Knowledge Gaps

Participants agreed that the highest priority, overarching knowledge gap is the need for epidemiological data that would help define the blast injury problem. When good epidemiological data are available, the remaining knowledge gaps will become clearer. There is a critical need to establish a common epidemiological database that links existing operational and medical databases. The participants agreed that the logical first step in establishing a common database is to link principal in-theater and autopsy medical databases and to determine the incidence and severity of blast exposures in Operation Iraqi Freedom (OIF). The logical

second step would be to link medical databases with Personal Protective Equipment (PPE) performance and incident databases to enable thorough analyses of PPE performance.

The participants also identified the following knowledge gaps within the four gap categories.

Protection

- Models: standardize and validate surrogate test models and nomenclature; develop a brain injury model; develop injury criteria.

- Primary and synergistic effects: determine the synergistic effects of primary and secondary blast injuries on tissue response and wound healing.

- Traumatic Brain Injury (TBI) effects: determine whether there is a TBI associated with primary blast.

- Repeat exposures: determine the effects of repeated blast exposures on areas besides the brain.

- Case identification methods: develop a better means of identifying cases of blast injury, especially those with milder injuries (unless the clinician is alerted to look for it, many brain injuries will be missed clinically).

- High-rate mechanical properties for biological tissues: determine how animal and human tissues respond to high rates of strain such as those experienced in blast injuries.

- Incident and injury linkages: analyze the effect of blast on body armor and subsequent injury.

- Data collection: collect more detailed incident and injury data, including more detailed autopsy data.

- Databases: develop robust epidemiological databases; standardize data definitions prior to merging of data.

- Individual differences: determine the effects of age, gender, and size on PPE performance.

- Neck injuries: determine the incidence of neck injuries and develop protection strategies.

- Environmental injury models: model the effects of inhaled toxic gases, including smoke and aerosols, associated with blast events.

Diagnostics

- Improved clinical data for mild injuries: develop and gain approval for field screening test(s) sensitive to mild TBI (mTBI) and vet through a nationally recognized panel; collect better clinical data on which to base a specific diagnosis of blast, post-traumatic stress disorder (PTSD), or other type of injury; develop a means to predict chronic injuries before they occur; determine the extent of subtle head injuries; and conduct basic research to determine whether blast overpressure can cause mTBI.

- Dosimeters to record biodynamic forces acting on the head: develop a dosimeter that can be worn in the combat helmet to measure and record the forces acting on the head during a blast exposure.

- Expand the use of biomarkers and study effects of multiple concussions: identify biomarker(s) of TBI that can distinguish mTBI from PTSD-like symptoms; develop a diagnostic tool, perhaps biomarkers that can predict the effects of multiple concussions; and identify biomarkers that can be used as prognostic indicators of lung/internal organ damage.

Treatment

- Clinical practice guidelines: conduct translational research validation for field clinical practice guidelines, especially for actions taken during the "platinum 10 minutes" and vet through nationally recognized expert panel.

- Neuroprotectants: develop better neuroprotectants for acute head injuries ranging from severe penetrating injuries to mTBI; develop additional solutions for increased intracranial pressure.

- Facial injuries: develop acute treatments of facial and eye injuries to mitigate damage and enhance repair (a better means of treating facial injuries is needed, as there are social implications) and consider how acute treatment affects longer-term reconstruction of the face and follow-on cosmetic surgery.

- Animal models: develop a better crosswalk between animal models and human treatment studies; study mechanical effects at the moment of impact and the molecular pathways behind the response to the impact.

- Freeze dried human plasma: develop better methods of getting freeze-dried human plasma to the medic on the battlefield.

Rehabilitation

- Limbs: explore new technologies in tissue regeneration as a possible means of repairing injured limbs and replacing lost limbs.

- Hearing loss studies with NIH: coordinate with other agencies, especially National Institutes of Health (NIH) agencies, for cochlear hair cell protection and repair and acute protection/restoration of hearing following impulse noise exposure.

- Auditory injury: consider a longitudinal study on hearing loss in conjunction with the Veterans Administration (VA); determine whether there is a correlation between hearing loss and cognitive performance decrements; improve screening of troops for hearing losses; and ensure collaboration between parallel service efforts on hearing loss.

- Drugs to treat hearing loss: accelerate research on drugs to treat noise-induced hearing loss and to regenerate cochlea hairs.

- Therapy: conduct more physical and occupational therapy research.

Medical Research Priorities

The panel reviewed the knowledge gaps and developed the following medical research priorities to fill the gaps.

Protection

1a. Link principal in-theater and autopsy medical databases and determine incidence and severity of blast exposures in OIF (the panel identified this as the highest priority gap and recommended it for immediate funding with available blast injury research funds).

1b. Link medical databases with PPE performance and incident databases to enable thorough analyses of PPE performance (i.e., the Joint Trauma Analysis and Prevention of Injury in Combat (JTAPIC) program).

2. Determine whether there is a traumatic brain injury associated with primary blast.

3. Characterize high-rate mechanical properties for biological tissues and soft materials; develop predictive constitutive and damage models; develop synthetic materials to mimic behavior of biological tissues.

4. Standardize and validate surrogate test models, nomenclature, and databases.

Diagnostics

1. Develop and gain approval for field screening test(s) sensitive to mTBI (vet through nationally recognized expert panel).

2. Expand capability for greater specificity with biomarker(s) of TBI (e.g., that distinguishes mTBI from PTSD-like symptoms).

3. Further enhance biomarker indicators for prognostic indicators of lung/internal organ damage.

Acute Treatment

1. Conduct translational research validation for field clinical practice guidelines, especially for actions in the "platinum 10 minutes," and vet through expert nationally recognized panel.

2. Develop acute treatments of facial and eye injuries to mitigate damage and enhance repair.

3. Develop better neuroprotectants for acute head injury, from severe penetrating injuries to mTBI, including solutions to increased intracranial pressure.

4. Coordinate research with other agencies, especially National Institutes of Health (NIH), on cochlear hair cell protection and repair/restoration of hearing following impulse noise exposure.

Return to Duty/"Reset"

1. Develop approaches to improve longer-term outcomes in concussive brain injury.

2. Develop criteria for withdrawal from duty for recovery and return to duty after concussive head injury/exposure.

3. Advance tissue regeneration methods, limb and other prosthetics, and repair and restoration of oral, dental and craniofacial tissues.

Proposed Strategy for the Future Management and Coordination of the Blast Injury Research Program

The panel suggested the following organizational structure to carry out the medical research coordination and management functions of the EA for the DoD Program on Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries. The panel recommended a two-level management strategy to assist the Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee.

1st level—Steering Committee coordinates agencies and activities as specific blast injury research issues are raised. Steering Committee members would include representatives from the organizations that were represented on the blast injury research meeting panel. The Steering Committee should be quad-service and include representation from the Department of Veterans. Additional members should include representatives from NIH, the Public Health Service, and possibly the Armed Forces Medical Examiner (AFME). The Steering Committee would make specific recommendations for the placement of funds.

2nd level—Executive Advisory Board – Flag Officers to review and approve recommendations submitted through the EA to the ASBREM. The board would consist of representatives from the four services.

Coordinating Office—An MRMC Coordinating Office would be established to provide EA administrative support.

Avoiding Duplicative Research and Building Cohesiveness

The participants recognized the need for synergistic research among the services, the VA, and other agencies. Duplicative research was recognized under the Directive as to be avoided. However, the value of "having more than one horse in the race" was recognized. Close coordination will be needed to avoid duplication.

A cohesive quad-service research program should be built upon. The program should be linked with commanders in the field, who can provide meaningful data. The program should be linked with other US military organizations that can provide relevant datasets or perform research. The other organizations are noted below.

Other Organizations to Involve in the Future

The participants recognized the need to involve several other organizations in future planning and research efforts. The involvement would occur at different levels, such as on standing committees and on subject matter expert panels. The participants recommended the involvement of the following organizations:

- Armed Forces Medical Examiner
- Aberdeen Test Center (ATC)
- US Army Institute of Surgical Research (USAISR)
- US Military Academy
- US Public Health Service
- Commanders in the field (to assist with improved data collection)
- VA
- NIH
- DoD research counterparts in Canada and Israel
- Academic research institutions.

The lead role of the VA in rehabilitative research was recognized early on by the participants. However, as acute treatment strongly affects the outcome of rehabilitative efforts, close interaction between DoD treatment providers and researchers and VA medical staff is needed.

The participants recognized the need to involve extramural players to provide subject matter expertise and a clear vision of what research is needed, where it is occurring, and opportunities for collaboration. These experts would also point out additional gaps.

The participants suggested the Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs as a means of involving academia and industry in developing technologies and products that the panel identifies as needed.

Future Objectives and Concerns to Address

The participants highlighted the following future blast injury research objectives and concerns:

- Quad-service participation and coordination should be increased.
- SBIR and STTR proposals should be used as a forum to increase participation by academia and industry.
- Sharing of datasets should be increased.
- There is a need to collect success stories and develop a positive focus.
- Some data may be classified; there may be a need to work through that barrier. Health Insurance Portability and Accountability Act (HIPAA) privacy requirements are a concern.

APPENDIXES

A. Abbreviations
B. Department of Defense Directive 6025.21E
C. Section 256 National Defense Authorization Act Fiscal Year 2006
D. Participant Invitation Letter
E. Meeting Agenda
F. Meeting Participants
G. Summaries of Presentations

A

Abbreviations

A&AS	Advisory and Assistance Services
AF	Air Force
AFIP	Armed Forces Institute of Pathology
AFME	Armed Forces Medical Examiner
AFRL	Air Force Research Laboratory
ARA	Applied Research Associates
ARL	Army Research Laboratory
ASBREM	Armed Services Biomedical Research Evaluation and Management
ATC	Aberdeen Test Center
ATD	Anthropomorphic Test Devices
ATO	Army Technology Objective
BICADS	Building Injury Calculator and Databases
BLUFIG	Blunt Filmed Glass
BLUUFG	Blunt Unfilmed Glass
BOP	Blast Overpressure
BTD	Blast Test Device
CERDEC	Communications-Electronics Research, Development, and Engineering Center
CEXCE	Combined Explosives Cell
CIDAP	Comprehensive Injury Data Analysis Platform
CTR	Combat Trauma Registry
DARPA	Defense Advanced Research Projects Agency
DDR&E	Director, Defense Research and Engineering
DoD	Department of Defense
DoDD	Department of Defense Directive
DTRA	Defense Threat Reduction Agency
DVBIC	Defense and Veterans Brain Injury Center
EA	Executive Agent
EOD	Explosive Ordnance Disposal
FDA	Food and Drug Administration
GDIT	General Dynamics Information Technology
GI	Gastrointestinal
HE	High Explosive

HIGS	Human Injury Gap Study
HIPAA	Health Insurance Portability and Accountability Act
HRC	Human Resources Command
HSTM	Human Surrogate Torso Model
IED	Improvised Explosive Device
JIEDDO	Joint IED Defeat Organization
JTAPIC	Joint Trauma Analysis and Prevention of Injury in Combat
JTR	Joint Travel Regulations
JTTR	Joint Theater Trauma Registry
MHGP	Multi-hit Glass Penetration
MOMRP	Military Operational Medicine Research Program
MOU	Memorandum of Understanding
MRMC	Medical Research and Material Command
mTBI	Mild Traumatic Brain Injury
MVC	Motor Vehicle Crash
NGBA	Next Generation Body Armor
NIH	National Institutes of Health
NIST	National Institute of Standards and Technology
NMRC	Naval Medical Research Center
NSC	Natick Soldier Center
OASD	Office of the Assistant Secretary of Defense
OASDHA	Office of the Assistant Secretary of Defense for Health Affairs
ODUSD(S&T)	Office of the Deputy Under Secretary of Defense for Science and Technology
OIF	Operation Iraqi Freedom
ONR	Office of Naval Research
OTSG	Office of the Surgeon General
PEC	Protection Engineering Consultants
PHS	Public Health Service
POM	Program Objective Management
PPE	Personal Protective Equipment
PTSD	Post-traumatic Stress Disorder
RAD	Research Area Directorate
RDECOM	US Army Research, Development, and Engineering Command
SAIC	Science Applications International Corporation
SAPI	Small Arms Protective Inserts
SBIR	Small Business Innovative Research
SECARMY	Secretary of the Army

SLAD	Survivability and Lethality Analysis Directorate
SME	Subject Matter Expert
SQ	SimQuest, LLC
STTR	Small Business Technology Transfer
TATRC	Telemedicine and Advanced Technology Research Center
TBI	Traumatic Brain Injury
TGAS	Toxic Gas Assessment Software
TSWG	Technical Support Working Group
UFR	Unfunded Requirement
USA	United States Army
USAARL	United States Army Aeromedical Research Lab
USAF	United States Air Force
USAISR	United States Army Institute of Surgical Research
USARIEM	United States Army Research Institute of Environmental Medicine
USN	United States Navy
USUHS	Uniformed Services University of the Health Sciences
VA	Veterans Administration
VAPO	Vulnerability Assessment and Vulnerability Option
WRAIR	Walter Reed Army Institute of Research
WRAMC	Walter Reed Army Medical Center

B

Department of Defense
DIRECTIVE

NUMBER 6025.21E
July 5, 2006
USD(AT&L)

SUBJECT: Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries
References:

(a) Section 256 of Public Law 109-163, "National Defense Authorization Act for Fiscal Year 2006"[1]
(b) DoD Directive 5101.1, "DoD Executive Agent," September 3, 2002
(c) DoD Directive 5134.3, "Director of Defense Research and Engineering (DDR&E),"November 3, 2003
(d) DoD Directive 5025.1, "DoD Directives System," March 2005
(e) through (g), see Enclosure 1

1. PURPOSE
This Directive:

1.1. Implements Reference (a) by establishing policy and assigning responsibilities governing coordination and management of medical research efforts and DoD programs related to prevention, mitigation, and treatment of blast injuries.

1.2. Designates the Secretary of the Army, in compliance with Reference (a) and consistent with Reference (b), as the DoD Executive Agent (DoD EA) for Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries according to Reference (b).

1.3. Establishes the Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee. The ASBREM Committee serves to facilitate coordination and prevent unnecessary duplication of effort within DoD biomedical research and development and associated enabling research areas, to include serving as the forum for implementation of subsections (d) and (g) of Reference (a).

2. APPLICABILITY
This Directive applies to:

2.1. The Office of the Secretary of Defense, the Military Departments, the Chairman of the Joint Chiefs of Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities in the Department of Defense (hereafter collectively referred to as the "DoD Components").

[1] Federal legislative information is available through the Library of Congress THOMAS site, http://thomas.loc.gov.

2.2. Medical and associated enabling research supported by any DoD Component for prevention, mitigation, and treatment of blast injuries.

3. DEFINITIONS

As used in this Directive, the following terms are defined as follows:

3.1. Blast Injury. Injury that occurs as the result of the detonation of high explosives, including vehicle-borne and person-borne explosive devices, rocket-propelled grenades, and improvised explosive devices. The blast injury taxonomy is provided at Enclosure 2.

3.2. Research. Any systematic investigation, including research, development, testing, and evaluation (RDT&E), designed to develop or contribute to general knowledge.

4. POLICY

It is DoD policy that:

4.1. DoD research related to blast injury prevention, mitigation, and treatment will be coordinated and managed by a DoD EA to meet the requirements, objectives, and standards of the DoD Military Health System as identified by the Under Secretary of Defense for Personnel and Readiness (USD(P&R)) and the unique combat casualty care requirements of the DoD Components.

4.2. Relevant research shall take maximum advantage of the scientific and technical capabilities of industry, academia, DoD Components, and other Federal Agencies.

4.3. The ASBREM Committee will be the venue for joint and cross-Service coordination specified by Reference (a).

4.4. DoD Components will gather and share medical information related to the efficacy of personal protective equipment and of vehicular equipment designed to protect against blast injury.

5. RESPONSIBILITIES AND FUNCTIONS

5.1. The Director of Defense Research and Engineering (DDR&E), under the Under Secretary of Defense for Acquisition, Technology and Logistics, according to DoD Directive 5134.3 (Reference (c)), shall:

5.1.1. Plan, program, and execute the functions and reports mandated for the DDR&E by Reference (a).

5.1.2. Have the authority to publish DoD Issuances consistent with Reference (d) for implementation of this Directive.

5.1.3. Establish, as needed, procedures to ensure that new technology developed under this Directive is effectively transitioned and integrated into systems and subsystems and transferred to and firmly under the control of the DoD Components.

5.1.4. Chair the ASBREM Committee to coordinate DoD biomedical research (see Enclosure 3 for additional detail), and employ that entity to facilitate the DoD EA's coordination and oversight of blast-injury research as specified in Reference (a).

5.1.5. Serve as the final approving authority for DoD blast-injury research programs.

5.1.6. Oversee the functions of the DoD EA and conduct/report on related periodic assessments (per Reference (a)).

5.2. The Assistant Secretary of Defense for Health Affairs (ASD(HA)), under the USD(P&R), shall:

5.2.1. Assist the DDR&E, the DoD EA, and the Director, Joint Improvised Explosive Devices Defeat Organization (JIEDDO), with identification of related operational and research needs, assessment of relevant research efforts, and coordination of planning to resolve capability gaps through focused research efforts.

5.2.2. Be the approving authority for Military Health System prevention and treatment standards developed and proposed by the DoD EA.

5.2.3. Appoint appropriate representatives to related coordinating boards or committees established by the DoD EA.

5.2.4. Ensure that the information systems capabilities of the Military Health System support the DoD EA and the functions specified by this Directive.

5.2.5. Serve as Co-chair of the ASBREM Committee. (See Enclosure 3 for additional detail.)

5.3. The Secretary of the Army is hereby designated as the DoD EA for Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries, consistent with Reference (a), to coordinate and manage relevant DoD research efforts and programs, and in that role shall:

5.3.1. Give full consideration to the Research and Engineering (R&E) needs of the DoD Components and the Director, JIEDDO, addressing those needs/requirements by:

5.3.1.1. Maintaining a DoD technology base for medical research related to blast injuries and based on the DDR&E-approved program for the DoD Components.

5.3.1.2. Performing programming and budgeting actions for all blast-injury research to maintain the R&E programs based on DDR&E-approved priorities of the DoD Components.

5.3.1.3. Programming and budgeting for blast-injury research based on analysis and prioritization of needs of the DoD Components, consistent with paragraph 5.1 of this Directive.

5.3.1.4. Executing the approved DoD blast-injury research program consistent with DoD guidance and availability of annual congressional appropriations.

5.3.2. Provide medical recommendations with regard to blast-injury prevention, mitigation, and treatment standards to be approved by the ASD(HA).

5.3.3. Coordinate DoD blast-injury-research issues with the staffs of the DDR&E, the ASD(HA), and the Director, JIEDDO.

5.3.4. Support the development, maintenance, and usage of a joint database for collection, analysis, and sharing of information gathered or developed by the DoD Components related to the efficacy of theater personal protective equipment (including body armor, helmets, and eyewear) and vehicular equipment designed to protect against blast injury.

5.3.5. Appoint a medical general or flag officer representative to the ASBREM Committee.

5.3.6. Ensure that information is shared as broadly as possible except where limited by law, policy, or security classification and that data assets produced as a result of the assigned responsibilities are visible, accessible, and understandable to the rest of the Department as appropriate and in accordance with Reference (e).

5.4. The Secretaries of the Navy and the Air Force shall:

5.4.1. Forward their respective approved blast-injury medical R&E requirements to the DoD EA for consideration and integration.

5.4.2. Appoint medical general or flag officer representatives to the ASBREM Committee and appoint representatives to any other coordination, oversight, or assessment board established by DDR&E or the DoD EA.

5.4.3. Coordinate with other DoD Components on the assignment of Joint Technical Staff Officers to Army medical research entities, research and acquisition organizations, or installations for coordination of research programming and execution needs pertaining to their Component.

5.4.4. Provide an appropriate system for identification, verification, prioritization, and headquarters-level approval of their respective blast-injury R&E requirements before submission to the DoD EA.

5.5. The President of the Uniformed Services University of the Health Sciences (USUHS), under the ASD(HA) and USD(P&R), shall:

5.5.1. Ensure that education relating to blast-injury prevention, mitigation, and treatment is included in the USUHS medical and continuing education curriculum and programs.

5.5.2. Appoint a representative to any coordination, oversight, or assessment board established by DDR&E or the DoD EA.

5.6. The Chairman of the Joint Chiefs of Staff shall:

5.6.1. Coordinate input to the DoD EA and ensure integration of the requirements processes of the Joint Capabilities Integration and Development System[2] with the processes employed under this Directive.

5.6.2. Appoint a relevant senior representative to the ASBREM Committee.

5.6.3. Appoint representatives to organizational entities of the ASBREM Committee and to any other coordination, oversight, or assessment board established by DDR&E or the DoD EA.

5.7. The Commander, U.S. Special Operations Command shall establish procedures and processes for coordination of relevant Defense Major Force Program 11 activities with those planned, programmed, and executed by the DoD EA and shall also:

5.7.1. Forward that command's approved blast-injury R&E requirements for consideration and integration to the DoD EA.

5.7.2. Appoint representatives to organizational entities of the ASBREM Committee, as appropriate, and to any other coordination, oversight, or assessment board established by DDR&E or the DoD EA.

5.7.3. Coordinate with the command on the assignment of Joint Technical Staff Officers to Army medical research entities, research and acquisition organizations, or installations for coordination of research programming and execution needs.

5.7.4. Provide an appropriate system for identification, verification, and headquarters-level approval of that command's blast-injury R&E requirements before submission to the DoD EA.

5.8. The Director, JIEDDO, consistent with Reference (f), shall:

5.8.1. Support development, maintenance, and usage of a joint database for collection, analysis, and sharing of information gathered or developed by DoD Components related to the efficacy of theater personal protective equipment (e.g., body armor, helmets, and eyewear) and vehicular equipment designed to protect against blast-injury.

5.8.2. Appoint representatives to organizational entities of the ASBREM Committee, as appropriate, and to any other coordination, oversight, or assessment board established by DDR&E or the DoD EA.

[2] CJCSI 3170.01E, "Joint Capabilities Integration and Development System," May 11, 2005, is available at http://www.dtic.mil/cjcs_directives/cjcs/instructions.htm.

5.8.3. Assist the DoD EA, the DDR&E, and the ASD(HA) with identification of related operational and research needs, assessment of relevant research efforts, and coordination of planning to resolve capability gaps through focused research efforts.

6. AUTHORITY

The DoD EA identified by this Directive is hereby delegated authority to do the following:

6.1. Obtain reports and information, consistent with the policies and criteria of DoD Directive 8910.1 (Reference (g)), as necessary, to carry out assigned responsibilities and functions.

6.2. Communicate directly with the Heads of the DoD Components, as necessary, to carry out assigned functions, including the transmission of requests for advice and assistance. Communications to the Military Departments shall be transmitted through the Secretaries of the Military Departments, their designees, or as otherwise provided in law or directed by the Secretary of Defense in other DoD issuances. Communications to the Commanders of the Combatant Commands shall normally be transmitted through the Chairman of the Joint Chiefs of Staff.

6.3. Communicate with other Federal Agencies, representatives of the Legislative Branch, members of the public, and representatives of foreign governments, as appropriate, in carrying out assigned responsibilities and functions. Communications with representatives of the Legislative Branch shall be coordinated with the Assistant Secretary of Defense for Legislative Affairs and the Under Secretary of Defense (Comptroller)/Chief Financial Officer, as appropriate, and be consistent with the DoD Legislative Program.

7. EFFECTIVE DATE

This Directive is effective immediately.

Enclosures – 3

E1. References, continued

E2. Taxonomy of Injuries from Explosive Devices

E3. ASBREM Committee

E1. ENCLOSURE 1
REFERENCES, continued

(e) DoD Directive 8320.2, "Data Sharing in a Net-Centric Department of Defense," December 2, 2004
(f) DoD Directive 2000.19E, "Joint Improved Explosive Device Defeat Organization (JIEDDO)," February 14, 2006
(g) DoD Directive 8910.1, "Management and Control of Information Requirements," June 11, 1993

E2. ENCLOSURE 2
TAXONOMY OF INJURIES FROM EXPLOSIVE DEVICES

E2.1.1. Primary. Blast overpressure injury resulting in direct tissue damage from the shock wave coupling into the body.

E2.1.2. Secondary. Injury produced by primary fragments originating from the exploding device (preformed and natural (unformed) casing fragments, and other projectiles deliberately introduced into the device to enhance the fragment threat); and secondary fragments, which are projectiles from the environment (debris, vehicular metal, etc.).

E2.1.3. Tertiary. Displacement of the body or part of body by the blast overpressure causing acceleration/deceleration to the body or its parts, which may subsequently strike hard objects causing typical blunt injury (translational injury), avulsion (separation) of limbs, stripping of soft tissues, skin speckling with explosive product residue and building structural collapse with crush and blunt injuries, and crush syndrome development.

E2.1.4. Quaternary. Other “explosive products” effects – heat (radiant and convective), and toxic, toxidromes from fuel, metals, etc. – causing burn and inhalation injury.

E2.1.5. Quinary. Clinical consequences of “post detonation environmental contaminants” including bacteria (deliberate and commensal, with or without sepsis), radiation (dirty bombs), tissue reactions to fuel, metals, etc.

E3. ENCLOSURE 3
ASBREM COMMITTEE

E3.1. ORGANIZATION AND MANAGEMENT

The ASBREM Committee shall:

E3.1.1. Consist of general and flag officer and Senior Executive representatives of relevant DoD Components.

E3.1.1.1. Standing members include relevant senior officials of the DoD Components. At a minimum, the DDR&E, the ASD(HA), and representatives of the DoD Components' Acquisition Executives.

E3.1.1.2. The standing membership may be expanded by invitation of the Chair when issues require senior-level coordination outside the scope of the principal members. Such invited members will include a medical flag officer from the Joint Staff, a designee of the DoD EA specified by this Directive, the Director, JIEDDO, the Director of the Combating Terrorism Technology Support Office, and others as appropriate.

E3.1.2. Be chaired by the DDR&E or Senior Executive designee and co-chaired by the ASD(HA) or Senior Executive designee.

E3.1.3. Convene at the discretion of the Chair and Co-chair.

E3.1.4. Invite the attendance of observers from DoD boards, committees or offices, or from other Federal Agencies with interests in the deliberations of the ASBREM Committee.

E3.1.5. Establish subcommittees, Joint Technology Coordinating Groups, and other entities, as required, to facilitate and execute committee business.

E3.2. FUNCTIONS

The ASBREM Committee shall:

E3.2.1. Review medical RDT&E program plans and accomplishments for quality, relevance, and responsiveness to military operational needs, the needs of the Military Health System, and the goals of Force Health Protection.

E3.2.2. Review program plans and budgets in support of the various guidance documents relevant to National Security and to the missions and functions of the Department of Defense.

E3.2.3. Provide coordination, recommendations, and support to DoD EA(s) and other DoD officials as requested, directed, or otherwise appropriate.

C

National Defense Authorization Act
Fiscal Year 2006

SEC. 256. PREVENTION, MITIGATION, AND TREATMENT OF BLAST INJURIES.

(a) DESIGNATION OF EXECUTIVE AGENT.—The Secretary of Defense shall designate an executive agent to be responsible for coordinating and managing the medical research efforts and programs of the Department of Defense relating to the prevention, mitigation, and treatment of blast injuries.

(b) GENERAL RESPONSIBILITIES.—The executive agent designated under subsection (a) shall be responsible for—

(1) planning for the medical research and development projects, diagnostic and field treatment programs, and patient tracking and monitoring activities within the Department that relate to combat blast injuries;

(2) efficient execution of such projects, programs, and activities; H. R. 1815—47

(3) enabling the sharing of blast injury health hazards and survivability data collected through such projects, programs, and activities with the programs of the Department of Defense;

(4) working with the Director, Defense Research and Engineering and the Secretaries of the military departments to ensure resources are adequate to also meet non-medical requirements related to blast injury prevention, mitigation, and treatment; and

(5) ensuring that a joint combat trauma registry is established and maintained for the purposes of collection and analysis of contemporary combat casualties, including casualties with traumatic brain injury.

(c) MEDICAL RESEARCH EFFORTS.—

(1) IN GENERAL.—The executive agent designated under subsection (a) shall review and assess the adequacy of medical research efforts of the Department of Defense as of the date of the enactment of this Act relating to the following:

(A) The characterization of blast effects leading to injury, including the injury potential of blasts in various environments.

(B) Medical technologies and protocols to more accurately detect and diagnose blast injuries, including improved discrimination between traumatic brain injuries and mental health disorders.

(C) Enhanced treatment of blast injuries in the field.

(D) Integrated treatment approaches for members of the Armed Forces who have a combination of traumatic brain injuries and mental health disorders or other injuries.

(E) Such other blast injury matters as the executive agent considers appropriate.

(2) REQUIREMENTS FOR RESEARCH EFFORTS.—Based on the assessment under paragraph (1), the executive agent shall establish requirements for medical research efforts described in that paragraph in order to enhance and accelerate those research efforts.

(3) OVERSIGHT OF RESEARCH EFFORTS.—The executive agent shall establish, coordinate, and oversee Department-wide medical research efforts relating to the prevention, mitigation, and treatment of blast injuries, as necessary, to fulfill requirements established under paragraph (2).

(d) OTHER RELATED RESEARCH EFFORTS.—The Director, Defense Research and Engineering, in coordination with the executive agent designated under subsection (a) and the Director of the Joint IED Defeat Task Force, shall—

(1) review and assess the adequacy of current research efforts of the Department on the prevention and mitigation of blast injuries;

(2) based on subsection (c)(1), establish requirements for further research; and

(3) address any deficiencies identified in paragraphs (1) and (2) by establishing, coordinating, and overseeing Department-wide research and development initiatives on the prevention and mitigation of blast injuries, including explosive detection and defeat and personnel and vehicle blast protection.

(e) STUDIES.—The executive agent designated under subsection (a) shall conduct studies on the prevention, mitigation, and treatment of blast injuries, including—

(1) studies to improve the clinical evaluation and treatment approach for blast injuries, with an emphasis on traumatic brain injuries and other consequences of blast injury, including acoustic and eye injuries and injuries resulting from over-pressure wave;

(2) studies on the incidence of traumatic brain injuries attributable to blast injury in soldiers returning from combat;

(3) studies to develop protocols for medical tracking of members of the Armed Forces for up to five years following blast injuries; and

(4) studies to refine and improve educational interventions for blast injury survivors and their families.

(f) TRAINING.—The executive agent designated under subsection (a), in coordination with the Director of the Joint IED Defeat Task Force, shall develop training protocols for medical and nonmedical personnel on the prevention, mitigation, and treatment of blast injuries. Those protocols shall be intended to improve field and clinical training on early identification of blast injury consequences, both seen and unseen, including traumatic brain injuries, acoustic injuries, and internal injuries.

(g) INFORMATION SHARING.—The executive agent designated under subsection (a) shall make available the results of relevant medical research and development projects and studies to—

(1) Department of Defense programs focused on—

(A) promoting the exchange of blast health hazards data with blast characterization data and blast modeling and simulation tools; and

(B) encouraging the incorporation of blast hazards data into design and operational features of blast detection, mitigation, and defeat capabilities, such as comprehensive armor systems which provide blast, ballistic, and fire protection for the head, neck, ears, eyes, torso, and extremities; and

(2) traumatic brain injury treatment programs to enhance the evaluation and care of members of the Armed Forces with traumatic brain injuries in medical facilities in the United States and in deployed medical facilities, including those outside the Department of Defense.

(h) REPORTS ON BLAST INJURY MATTERS.—

(1) REPORTS REQUIRED.—Not later than 270 days after the date of the enactment of this Act, and annually thereafter through 2008, the Secretary of Defense shall submit to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives a report on the efforts and programs of the Department of Defense relating to the prevention, mitigation, and treatment of blast injuries .

(2) ELEMENTS.—Each report under paragraph (1) shall include the following:

(A) A description of the activities undertaken under this section during the two years preceding the report to improve the prevention, mitigation, and treatment of blast injuries.

(B) A consolidated budget presentation for Department of Defense biomedical research efforts and studies related to blast injury for the two fiscal years following the year of the report.

(C) A description of any gaps in the capabilities of the Department and any plans to address such gaps within biomedical research related to blast injury, blast injury diagnostic and treatment programs, and blast injury tracking and monitoring activities.

(D) A description of collaboration, if any, with other departments and agencies of the Federal Government, and with other countries, during the two years preceding the report in efforts for the prevention, mitigation, and treatment of blast injuries.

(E) A description of any efforts during the two years preceding the report to disseminate findings on the diagnosis and treatment of blast injuries through civilian and military research and medical communities.

(F) A description of the status of efforts during the two years preceding the report to incorporate blast injury effects data into appropriate programs of the Department of Defense and into the development of comprehensive force protection systems that are effective in confronting blast, ballistic, and fire threats.

(i) DEADLINE FOR DESIGNATION OF EXECUTIVE AGENT.—The Secretary shall make the designation required by subsection (a) not later than 90 days after the date of the enactment of this Act.

(j) BLAST INJURIES DEFINED.—In this section, the term ‘‘blast injuries’’ means injuries that occur as the result of the detonation of high explosives, including vehicle-borne and person-borne explosive devices, rocket-propelled grenades, and improvised explosive devices.

(k) EXECUTIVE AGENT DEFINED.—In this section, the term ‘‘executive agent’’ has the meaning provided such term in Department of Defense Directive 5101.1.

D

Participant Invitation Letter

Dear Meeting Participants:

On behalf of Dr. John Frazier Glenn, the Principal Assistant for Research and Technology, U.S. Army Medical Research and Materiel Command (MRMC), thank you for agreeing to participate in the MRMC blast injury research planning meeting scheduled for Monday, 10 Jul 06. This meeting is designed for the UNCLASSIFIED level. The meeting will be held at the Holiday Inn-Frederick Holidome and Conference Center, 5400 Holiday Drive, Frederick, MD 21703. A meeting agenda, a listing of participants, and directions to the meeting site are attached to this message.

MRMC has organized this meeting under the new DoD program on, "Medical Research for Prevention, Mitigation and Treatment of Blast Injuries."
The DoD Program is described in the attached draft DoD Directive.
Please note that this Directive is a final draft awaiting signature by the Deputy Secretary of Defense. The objectives of the meeting are: to briefly review each organization's past, present, and planned (i.e.,
funded) blast injury research projects; to identify and prioritize critical knowledge gaps that will not be filled by the existing portfolio of current and planned research projects; and, to identify and recommend research projects to receive immediate funding that will significantly contribute knowledge that will help to close the identified gaps. The total funding immediately available is less than $1.3M for all projects together. One or more projects are expected to be supported with funding that must be expended within one year and with heavy reliance on existing infrastructure (i.e., limited support to new equipment).

The meeting will include a morning session, a working lunch, and an afternoon session. During the morning session, each researcher or representative from sponsoring organizations will present a 15-min, open (nonproprietary, unclassified) programmatic overview of their past, present, and planned (i.e., funded) blast injury research projects. The afternoon session will include a facilitated discussion among panel members and presenters to discuss critical knowledge gaps that will not be filled by current or planned research projects based on information presented during the morning session. The participants will break following this facilitated discussion, and the panel will reconvene in a closed session for the remainder of the day. During this closed session the panel will develop a final listing of knowledge gaps; identify research projects to receive immediate funding that will significantly contribute knowledge that will help to close the knowledge gaps; identify key participants (by organization and individual) in future Blast Program development forums, working groups, and review panels; and, recommend project funding priorities for consideration by the Director, Defense Research and Engineering.

Note to presenters: The purpose of your presentation is to provide information to the review panel that will enable them to identify critical gaps in the current state of blast injury knowledge. Therefore, your presentation should answer the following three questions about your organization's blast injury research or the blast injury research it

sponsors: (1) what have you accomplished? (2) What are you currently doing? (3) What are you funded to do next? Please do not address your capabilities or your unfunded proposals for future research. Also, you will be limited to 15 minutes for your presentation, including time for questions and answers, so you must present a broader programmatic view, rather than a detailed scientific view of your research. An LCD projector and dedicated laptop computer will be available for presenters. Please bring your presentation on a CD ROM or removable hard drive so it can be loaded prior to the beginning of the morning session.

Note to observers: Given the ambitious agenda and objectives for this meeting, we must ask that questions and discussion be restricted to the interaction between panel members and presenters.

Note to Out-of-Town Attendees: Rooms have been reserved for out-of-town attendees at the Holiday Inn at a rate of $78.00 per night plus tax.
You should call, 301-694-7500, as soon as possible if you plan to stay at the Holiday Inn. If you need assistance with the lodging, please feel free to call our POC here at General Dynamics, Ms. Helene Fredericks, at 301-628-2952.

If you have any questions about this meeting, please don't hesitate to contact me, or contact Dr. Catherine Schempp (General Dynamics Information Technology) at 301-628-2936, catherine.schempp@gdit.com.

Again, thank you for your willingness to participate in this meeting.
We look forward to seeing you on the 10th.

V/R,

Mike Leggieri

Mr. Michael J. Leggieri, Jr.
Senior Technical Director
General Dynamics Information Technology (GDIT)

U.S. Army Medical Research and Materiel Command Military Operational Medicine Research Program
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E

US Army Medical Research and Materiel Command (MRMC)
Blast Injury Research Planning Meeting
Frederick, Maryland
AGENDA

Monday, July 10, 2006	
0730—0800	**Continental Breakfast**
0800—0815	**Welcome, Administrative Remarks, and Panel Member Introductions** *Dr. George Lewis, General Dynamics Information Technology (contract support to MRMC)*
0815—0830	**Meeting Objectives and Charge to Participants** *Dr. John F. Glenn, Principal Assistant for Research and Technology, MRMC*
Presentations	
0830—0845	**MRMC Combat Casualty Care Research Program Blast Injury Research Programs** *COL Robert Vandre, MRMC, Research Area Directorate 2 (RAD2)*
0845—0900	**MRMC Military Operational Medicine Research Program (MOMRP) Blast Injury Research Programs** *LTC Carl Hover, MRMC, RAD3*
0900—0915	**MRMC Military Operational Medicine Research Program (MOMRP) Blast Injury Research Programs (cont)** *Dr. John Crowley, U.S. Army Aeromedical Research Laboratory*
0915—0930	**US Army Natick Soldier Center (NSC) Blast Injury Research Programs** *Mr. Michael Maffeo, NSC*
0930—0945	**US Army Research Laboratory's (ARL) Survivability and Lethality Analysis Directorate (SLAD) Blast Injury Research Programs** *Mr. Gregory Dietrich, ARL/SLAD*
0945—1000	**Defense and Veterans Brain Injury Center (DVBIC) Blast Injury Research Programs** *Dr. Warren Lux, DVBIC*
1000—1015	**Break**

Presentations (continued)	
1030—1045	**Defense Advanced Research Projects Agency (DARPA) Blast Injury Research Programs** *COL Geoffrey Ling, DARPA*
1045—1100	**Naval Medical Research Center (NMRC) Blast Injury Research Programs** *Dr. Keith Prusaczyk, NMRC*
1100—1115	**Office of Naval Research (ONR) Blast Injury Research Programs** *CDR Russell Shilling, ONR*
1115—1130	**Air Force Science and Technology Blast Injury Research Programs** *Lt. Col. Patrick Bradshaw, AQRT*
1130—1145	**Defense Threat Reduction Agency (DTRA) Advisory and Assistance Services (A&AS) Blast Injury Research Programs** *Dr. Chuck Oswald, Protection Engineering Consultants*
1145—1200	**Applied Research Associates (ARA) Blast Injury Research Programs** *Ms. Lee Ann Young, ARA*
1200—1300	**Working Lunch**
Facilitated Session (Open Session)	
1300—1430	**Panel Members and Presenters Identify Critical Knowledge Gaps** *Group Discussion Led by Dr. George Lewis*
1430—1500	**Break**
Review Panel Members (Closed Session)	
1500—1700	**Panel Validates List of Knowledge Gaps and Develops Organizational Concepts for Blast EA Management** *COL Karl Friedl, US Army Research Institute of Environmental Medicine, Panel Chair*
Adjourn	

F

Meeting Participants

Panel Members

COL Karl Friedl, USA, Panel Chair
Commander, US Army Research Institute of Environmental Medicine
Ft. Detrick, Maryland

Mr. William Albright
Combating Terrorism Technology Support Office-Technical Support Working Group
Arlington, Virginia

COL Cynthia Bedell, USA
US Army Research, Development, and Engineering Command
Fort Belvoir, Virginia

Dr. Howard Champion
Uniformed Services University of the Health Sciences (USUHS)
Bethesda, Maryland

COL David Chandler, USA
Office of the Surgeon General
Falls Church, Virginia

Dr. Salvatore Cirone
Office of the Assistant Secretary of Defense for Health Affairs
Falls Church, Virginia

COL Robert DeFraites, USA
U.S. Army Medical Research and Materiel Command (MRMC)
Fort Detrick, Maryland

CAPT Douglas Forcino, USN
Office of Naval Research (ONR)
Arlington, Virginia

Dr. Steve Kaminsky
USUHS
Bethesda, Maryland

LTC Keith Martin, USA
MRMC
Fort Detrick, Maryland

LTC John Masterson, USA
Joint Improvised Explosive Device Defeat Organization
Pentagon, Washington, District of Columbia

Col. James R. Riddle, USAF
Air Force Research Laboratory
Wright-Patterson Air Force Base, Ohio

Presenters

Dr. John Crowley
US Army Aeromedical Research Lab
Fort Rucker, Alabama

Mr. Gregory Dietrich
US Army Research Laboratory Survivability/Lethality Analysis Directorate (SLAD)
Aberdeen Proving Ground, Maryland

LTC Carl Hover, USA
MRMC Military Operational Medicine Research Program
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COL Geoffrey Ling, USA
Defense Advanced Research Projects Agency
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Dr. Warren Lux
Defense and Veterans Brain Injury Center
Washington, D.C.

Mr. Michael Maffeo
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Natick, Massachusetts

Lt. Col. Patrick Bradshaw, USAF
Acquisition, Science, Technology, and Engineering
Washington, D.C.

Dr. Keith Prusaczyk
Naval Medical Research Center
Silver Spring, Maryland

CDR Russell Shilling, USN
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Dr. Chuck Oswald
Protection Engineering Consultants
Contract Support to Defense Threat Reduction Agency Advisory and Assistance Services
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COL Robert Vandre, USA
MRMC Combat Casualty Care Research Program
Fort Detrick, Maryland

Ms. Lee Ann Young
Applied Research Associates, Inc.
San Antonio, Texas

Guests

COL Raj Gupta
Walter Reed Army Institute of Research
Silver Spring, MD

Mr. Bart Kuhn
BioSystems, Office of the Deputy Under Secretary of Defense for Science and Technology
Department of Defense

Mr. Daniel Miller
Army Research Laboratory
Adelphi, Maryland

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SAIC
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Mr. John Uscilowicz
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COL Nancy Vause, USA
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Meeting Staff
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Mr. Michael Leggieri
Project Director

Dr. Catherine Schempp
Project Assistant

Dr. George Lewis
Meeting Facilitator

Ms. Helene Fredericks, CMP, CGMP
Meeting Planner

Ms. Sue Tripp
Technical Writer

G

Summaries of Presentations

As provided by presenters

MRMC Combat Casualty Care Research Program Blast Injury Research Programs: *COL Robert Vandre, MRMC, RAD 2***

MRMC Military Operational Medicine Research Program (MOMRP) Blast Injury Research Programs: *LTC Carl Hover, MRMC, RAD 3*

MRMC Military Operational Medicine Research Program (MOMRP) Blast Injury Research Programs: *Dr. John Crowley, U.S. Army Aeromedical Research Laboratory***

US Army Natick Soldier Center (NSC) Blast Injury Research Programs: *Mr. Michael Maffeo, NSC*

US Army Research Laboratory's (ARL) Survivability and Lethality Analysis Directorate (SLAD) Blast Injury Research Programs: *Mr. Gregory Dietrich, ARL/SLAD*

Defense and Veterans Brain Injury Center (DVBIC) Blast Injury Research Programs: *Dr. Warren Lux, DVBIC*

Defense Advanced Research Projects Agency (DARPA) Blast Injury Research Programs: *COL Geoffrey Ling, DARPA***

Naval Medical Research Center (NMRC) Blast Injury Research Programs: *Dr. Keith Prusaczyk, NMRC***

Office of Naval Research (ONR) Blast Injury Research Programs: *CDR Russell Shilling, ONR***

Air Force Science and Technology (AQRT) Blast Injury Research Programs: *Lt. Col. Patrick Bradshaw, AQRT*

Defense Threat Reduction Agency (DTRA) Advisory and Assistance Services (A&AS) Blast Injury Research Programs: *Dr. Chuck Oswald, Protection Engineering Consultants*

Applied Research Associates (ARA) Blast Injury Research Programs: *Ms. Lee Ann Young, ARA*

**Summary not provided by the presenter for inclusion in proceedings

MRMC Military Operational Medicine Research Program (MOMRP) Blast Injury Research Programs: *LTC Carl Hover, MRMC, RAD 3*

The Military Operational Medicine Research Program (MOMRP) has been a world-leading blast injury research organization for more than 25 years. Our biomedical research addresses the entire spectrum of blast injuries, including injuries from blast overpressure, blunt trauma, and inhaled toxic gases. Our objectives are to develop a thorough understanding of the fundamental mechanisms of injury, to develop mathematical models to allow predictions of these injuries, and to develop guidance to the user community in the correct application of our blast injury prediction models and our health hazard and survivability assessment tools. Our blast injury research projects are summarized below.

1. Blast Overpressure (BOP) Lung Injury Prediction Tool (completed). The MOMRP completed an extensive BOP non-auditory injury research project spanning nearly two decades. The project included advanced biomechanical modeling methods and extensive large animal (sheep) blast injury tests in a variety of complex blast environments. The research produced a predictive model of lung injury from BOP exposure packaged in a software application known as "INJURY." INJURY has been reviewed by independent scientific panels and published in the open scientific literature, and it has been validated for occupational and lethal exposures to conventional and novel blast. INJURY is currently used by the Army's health hazard and survivability assessment programs.

2. Inhalation Injury Prediction Tool (completed). The MOMRP completed an extensive research program focused on the toxic fire gas exposure hazards that Warfighters face behind defeated armor. The research combined advanced systemic and biomechanical modeling techniques with extensive small animal tests to produce a predictive model of incapacitation and injury from mixed fire gas exposures. The model is packaged in a software application known as the Toxic Gas Assessment Software (TGAS). The MOMRP has delivered TGAS to the Army's survivability assessors to support live-fire survivability tests.

3. Body Armor Blunt Trauma Assessment Tool (current). The MOMRP is completing a project to develop a new body armor blunt trauma performance testing method. The project combined large animal (porcine) tests with advanced medical imaging and mathematical modeling methods to produce a predictive model of blunt trauma injury behind body armor. The research product is a body armor testing apparatus with the injury prediction model packaged in a software application. By the end of FY06, the MOMRP will deliver this new testing method to the Army's body armor developers, who will use it as a research tool to evaluate the performance of novel, lightweight ballistic materials.

4. Historical Blast Bioeffects Data Preservation (current). The MOMRP possesses an extensive archive of blast bioeffects data that were produced by various Defense agencies at Kirtland Air Force Base over a 50-year period. These data represent the free world's knowledge of blast bioeffects. Studies included a wide range of animal species ranging from mice to oxen and exposure conditions that included exposures in the open, in buildings, in enclosures, and under water. The nature and scope of these animal studies may never be repeated. The test site closed in 1998 and most researchers are gone. Without an active effort, valuable data from this

extensive work will be lost. In 1998, the MOMRP initiated a multi-year project to inventory and archive these data and to format “hard” data in a form that can be readily accessed by researchers working on emerging blast threats.

5. Planned Research. The MOMRP's FY07-13 research program will advance the individual blast, blunt trauma, and inhalation injury models beyond the current endpoints of injury and incapacitation to address the endpoints of physical and cognitive performance. We will expand the individual models to address the effects of altitude, temperature, humidity, and the differences in individual characteristics, such as age, gender, and size that can significantly influence the outcome of blast insults. Ultimately, the MOMRP will combine the individual models into a single, integrated model of blast, blunt trauma, and inhalation injury. The MOMRP will also continue the historical blast bio-effects data preservation project.

US Army Natick Soldier Center (NSC) Blast Injury Research Programs: *Mr. Michael Maffeo, NSC*

Natick Soldier Center currently has two programs focused on Blast Protection: Individual Protection against Novel Blast Threats (recently merged into Soldier Ballistic/Blast Protection Army Technology Objective (ATO)) and Development of Performance Standard for Explosive Ordnance Disposal Suits.

Individual Protection against Novel Blast Threats: This program is focused on providing protection against primary blast lung injury for novel/thermobaric threats in a confined, complex environment. The products of this effort include 1) an add-on protective concept for the Interceptor Body Armor (by the end of FY06) and 2) an integrated protective concept for the Future Force Warrior (by the end of FY07).

To accomplish this program, NSC has partnered with MRMC. Personnel from the Walter Reed Army Institute of Research (WRAIR) are part of the team established to conduct lethality analysis for the program. L3 Communications (formerly Jaycor) is being funded to modify the existing Blast Test Device (BTD) to test materials concepts and to validate this modification by correlating this data with lethality data generated.

Two other behind armor blunt trauma torso surrogates have been purchased under the program as research devices to test armor effects. These devices are the AUSMan (DSTO Australia/University of Virginia), and the Human Surrogate Torso Model (HSTM) (ONR/Johns Hopkins University). A limited amount of testing has been conducted with each of these devices in a blast environment.

As part of the program, the performance of the Interceptor Body Armor (with Small Arms Protective Inserts (SAPI) plate) in a blast environment was quantified. The results indicate that wearing body armor in a blast does not increase lethality when compared to the unprotected condition. Specific results can be made available to the panel if there is interest. This is the first significant result for lethality effects of body armor in a blast environment.

Testing will continue through the rest of FY06 to demonstrate a protective concept for use with Interceptor Body Armor. Testing in FY07 will quantify the performance of the Future Force Warrior body armor system and demonstrate an integrated materials solution for blast protection.

Development of Performance Standard for Explosive Ordnance Disposal Suits: This effort is funded by the National Institute of Standards and Technology (NIST). Currently there is no objective standard in place for evaluation of explosive ordnance disposal (EOD) Personal Protective Equipment (PPE). The threat for the EOD standard is a typical pipe bomb at a standoff distance of 2 feet. The intended user for this standard is the first responder/civilian EOD community.

Under this program, testing was performed with human torso surrogates (Hybrid III and AUSMan), porcine, and human cadavers. Blast induced brain injury effects were identified. A final report is expected to be completed by December 2006.

NSC recommendations:

- Continue research into body armor options for blast/ballistic protection in an integrated ensemble
- Promote research for high strain rate material properties to foster development of finite element models of the human torso and the behavior of the torso during blast exposure
- Promote research establishing correlation between blast effects on animals and humans to allow scaling of extant data for development of blast mitigation and protection.

Other historical work not presented to the Blast Injury Mitigation Panel: Blast Metrics Working Group (2004) - This NSC program was funded by DARPA to develop a baseline set of metrics for lung injury, potentially discerning the effects of conventional blast and thermobaric blast effects, providing a quantitative scale to assess the efficacy of proposed countermeasures (protective clothing, active measures), and assessing the effects of room geometry on blast effects. The summary of this work included the following recommendations:

- Investigation into the central nervous system effects of blast exposure.
- Further "mining" extant data on human effects and injuries in recent bombings.
- Development of a time-based incapacitation scale, i.e., Functional Capacity Index.
- Development of models of medical consequences that incorporate both fragment and burn injuries and/or modeling the effect of mitigators such as body armor.

This draft report was presented to DARPA in 2004. If there is interest from the panel in obtaining this report, NSC could inquire about the possibility of distributing the report to the panel members

US Army Research Laboratory's (ARL) Survivability and Lethality Analysis Directorate (SLAD) Blast Injury Research Programs: *Mr. Gregory Dietrich, ARL/SLAD*

The U.S. Army Research Laboratory's Survivability/Lethality Analysis Directorate (ARL/SLAD) is the Army's primary source of survivability, lethality, and vulnerability (SLV) analysis and evaluation support, adding value over the entire system life cycle. ARL/SLAD's efforts ensure that our Soldiers and systems can survive and function on the battlefield. ARL/SLAD is committed to assisting the Army in achieving its goals by helping acquire systems to help Soldiers survive in all environments against the full spectrum of battlefield threats. ARL/SLAD's value to the Army is based upon its unique SLV scientific and engineering skills and its unique analytical tools used to conduct SLV investigations, simulations, and lab/field experiments. ARL/SLAD holds extensive expertise and experience in various areas related to blast research, including 1) methodology, modeling and simulation (M&S) analytical tool development and application; 2) combat casualty assessment and analysis; 3) trauma and wound ballistics; and 4) soldier survivability and vulnerability assessment. Current (and for the past 5 decades) blast injury research involves characterizing injury/incapacitation due to kinetic energy projectiles (e.g., fragments, bullets, flechettes, etc.), blast-overpressure, thermal/burn, acceleration/deceleration, toxic gases/substances, as well as others. Also, ARL/SLAD has the Army's mission to conduct Congressionally-mandated ballistic and non-ballistic threat/insult crew casualty assessments (CCA) for Live-Fire Testing & Evaluation (LFT&E). Non-ballistics LFT&E CCA assessments are often conducted jointly with MRMC/WRAIR. Also, ARL/SLAD conducts CCA for Joint Live-Fire testing (JLF) and for various other soldier and soldier-system testing; including weapons- and munitions anti-personnel effects testing, Additionally, ARL/SLAD is the Army's mission proponent for "Soldier Survivability" – the 7th domain of the Army's MANPRINT Program. ARL/SLAD's mission and programs directly support the soldier, including responding to urgent in-theater requests related to anti-personnel effects of weapons/munitions and individual protection effectiveness evaluation (e.g., body armor, helmets, etc.) for both dismounted troops, as well as for vehicle-crew member systems (e.g., for combat and non-combat vehicles). ARL/SLAD recommends the following list of proposed project areas to improve the Army's blast injury research capabilities:

1. Conduct extensive field testing of inventoried munitions (and non-inventoried munitions) taking into account how they are presently employed in-theater (includes IEDs) in order to more accurately quantify the total blast insult-threat (e.g., blast-overpressure, fragment, shell, energized debris, etc.) to close proximity service members.
2. Improve soldier survivability/personnel vulnerability injury/incapacitation M&S tools that directly support the Army's blast/body armor/survivability analysis.
3. Improve methods that quantitatively characterize both fatal and nonfatal injury patterns due to battlefield blast (all mechanisms); and correlate to ORCA Model predictions.
4. Increase collaboration with Medical Command elements to utilize combat casualty data to improve blast/body armor effectiveness analysis & M&S.
5. Develop evidence-based combat casualty injury patterns (fatal and non-fatal) due to specific in-theater munition-type/configuration-environment scenarios.

6. In collaboration with Medical Command elements, develop medical resource requirement (e.g., triage/treatment) into Army's operational casualty modeling tools in order to improve survivability & body armor analysis and M&S.
7. With Medical Command, investigate novel hypotheses for blast-induced TBI.
8. In collaboration with Medical Command, test & evaluate (toward improving) current blast experimental data collection instrumentation (e.g., MRMC's BTD), to include increasing its survivability and applicability during blast testing research.

Defense and Veterans Brain Injury Center (DVBIC) Blast Injury Research Programs: *Warren Lux, M.D., DVBIC*

Traumatic Brain Injury (TBI) Clinical Research Considerations

- Blast exposure can produce both penetrating and closed TBI by a number of mechanisms that are well understood. These include secondary injuries (impact from blast-energized debris, penetrating and non-penetrating), tertiary injuries (displacement of the person – or at least the head – by the blast), and injuries acquired when the blast is associated with a motor vehicle crash (MVC).
- The pathology, distribution, and clinical consequences of these types of injuries are also relatively well understood, including the mild (concussive) closed TBIs as well as the moderate and severe closed TBIs and the penetrating TBIs.
- Data are limited, however, with regard to the effects on the brain of the primary blast wave itself, as well as the quaternary injuries (inhalation of toxic gases).
- When studying the problem clinically, an important methodological consideration is that most, perhaps all, patients who sustain a TBI in an actual blast have at least a secondary and/or tertiary injury, sometimes with an MVC.
- A corollary is that "pure" primary blast TBI patients are hard, perhaps impossible, to identify, and even then, associated quaternary injury is difficult to rule out.
- Against this background, then, the major clinical research questions are:
  - Does acquiring a TBI in a blast environment result in damage to the brain beyond that caused by the secondary and tertiary injuries or associated MVCs?
  - If so, what is the pathology of that damage, what is its distribution, and what are the clinical consequences?
  - Are the long-term outcomes different, particularly in relation to standard measures of severity that have been defined for non-blast closed TBI?
  - What are the roles of major co-morbidities, including associated acute physical and psychological injuries, as well as chronic conditions such as limb amputation, PTSD, epilepsy, substance use disorders, etc.?
- The Defense and Veterans Brain Injury Center (DVBIC) has been screening all patients at Walter Reed who were injured in a blast since January 2003. In this relatively severely injured cohort, 40 percent had a TBI. A little more than half of the TBIs were moderate, severe, or penetrating. The remainder was mild.
- DVBIC has also participated in TBI screening in selected post-deployment cohorts. A history of mild TBI while deployed was obtained in nearly 12 percent.
- Current DVBIC research includes characterization of blast vs. non-blast TBI in multiple domains, including the general medical and surgical, neurological, neuropsychological, neurobehavioral/psychiatric, neuro-imaging (MRI/fMRI), and biochemical (biomarkers) domains.
- Funded DVBIC research that will begin in 2006 will include studies of MRI/DTI, substance use disorders, and efficacy of a low-cost telephonic clinical intervention in patients with blast vs. non-blast TBI and will also include a longitudinal study of cognitive change from baseline after in-theater blast exposure, with or without associated TBI.

Air Force Science and technology Blast Injury Research Programs: *Lt Col Patrick Bradshaw, AQRT*

Category: Blast Injury Characterization

- Program name: IED Injury Criteria
- POC: AFRL/HEPA; Ted Knox, PhD
- Collaborators: AFRL/HECB; Singapore DSO; FIA Safety Lab; 4 SBIR Contractors; NHTSA; industry partners
- Goal: Develop and deploy a method to capture head accelerations imparted by bullets, blast and crash
- Approach: Develop new data capture and analysis methods that the modeler can use to determine the validation level of injury models
- Program Information: Start: FY06; Finish: FY09
- Product: Low cost sensor systems to characterize acceleration data, correlate to injury
- Benefit: Improvised Explosive Device (IED) blast modeling and injury prediction, and ensured personnel performance and protection

Category: Blast Injury Protection, Mechanical

- Program name: Conformal Body Armor
- POC: AFRL/MLLMP, 1stLt Mark Mallory; AFRL/HEPA, Capt. Atul Phadke
- Collaborators: AFRL (HE, ML); Force Protection Battlelab; industry partners
- Goal: Produce Shaped/Contoured Armor
- Approach: Utilize AFRL/HE body scanning technology; Leverage Excera Materials unique manufacturing; Manufacture complex Ceramic-Metal armor shapes
- Program Information: $200k; Start: FY06; Finish: FY07
- Product: Conformal Body Armor proof of concept
- Benefit: Better fitting, low-cost, less intrusive, more effective body armor

Category: Blast Injury Protection, Neurological

- Program name: Environmental Effects on TBI Vulnerability/Recovery
- POC: AFRL/HEPA, Catherine Harrison, PhD
- Collaborators: AFRL/HEPA; University of Ottawa; Carleton University; Tel Aviv University
- Goal: Reduce incidence and severity of TBI
- Approach: Apply environmental enrichment before and after trauma to evaluate interactive effects
- Program Information: Start: FY06; Finish: FY06
- Product: First-ever data linking pre and post-injury environmental conditions to brain injury prognosis
- Benefit: Rapid transition to DVBIC collaboration Higher providing improved long-term quality of life to blast-induced brain injury survivors

Category: Blast Injury Diagnosis

- Program name: Early Diagnosis of Mild Traumatic Brain Injury
- POC: AFRL/HEPA, Ted Knox, PhD

- Collaborators: AFRL/HEPA; U. Cincinnati; U. Miami; Columbia U.; Duke U.; Wright State U.; ASAARL; NIRx; Drexel; industry partners
- Goal: Develop and deploy a device to detect mild to moderate TBI well forward on the battlefield
- Approach: Develop multi-spectral data capture and analysis methods to identify mild TBI
- Program Information: Start: FY06; Finish: FY09
- Product: A small, low-cost device to detect mild to moderate TBI well forward on the battlefield
- Benefit: Detection of mild to moderate brain injury currently undiagnosed, earlier and more effective treatment

Category: Blast Injury Characterization

- Program name: Human Modeling for Injury Assessment from Blast (HMIAB)
- POC: AFRL/HEPA, Nathan Wright
- Collaborators: AFRL/HEPA; AFRL/ML; Singapore DSO; CFDRC; Wallace Kettering Neuroscience Institute
- Goal: Develop tools to guide design of equipment to mitigate brain and whole body injury
- Approach: Quantify blast wave signatures of representative IEDs; build a whole-body response model; build a brain model including fluid space and vasculature
- Program Information: Start: FY06; Finish: FY09
- Product: Computational tools to accurately model whole body biodynamics and brain response to blast waves
- Benefit: Characterization of causes of mild TBI, guiding design of equipment to mitigate blast injury

Category: Blast Injury Treatment

- Program name: Enhanced Neuro-rehabilitation for TBI
- POC: AFRL/HEPA, Catherine Harrison, PhD; DVBIC, Warren Lux, MD
- Collaborators: AFRL/HEPA; DVBIC, Conemaugh Brain Injury Center
- Goal: Return TBI survivors to pre-injury function
- Approach: Develop and test therapy using environmental enrichment to mitigate TBI in OIF veterans
- Program Information: Start: FY07; Finish: FY10
- Product: Effective, neuroscience-based neuro-rehabilitation for blast-induced brain injury
- Benefit: Improve outcome and reduce cost with environmental rehabilitation; Identify and eliminate rehabilitation redundancies

Defense Threat Reduction Agency (DTRA) Advisory and Assistance Services (A&AS) Blast Injury Research Programs: *Dr. Chuck Oswald, Protection Engineering Consultants*

Accomplishments:
DTRA involvement in human injury to date has focused on injuries from large terrorist bombs, which happen overwhelmingly to occupants of nearby buildings.

1. DTRA has overseen approximately 20 tests where anthropomorphic test devices (ATDs) and instrumented cadavers placed behind filmed and unfilmed windows and tent and wood expeditionary structures overloaded by blast from large high-explosive (HE) tests in Devine Buffalo and BAITS test series. These tests directly determined blunt trauma injuries to human models from actual blast-induced building debris.
2. DTRA has also overseen testing to help define debris field from buildings overloaded by blast:
   - Shock tube testing on annealed and tempered glass to determine glass shard flyout model as input for penetrating injury debris model
   - HE tests on typical wood frame walls.
3. DTRA has overseen development of engineering models for injury of building occupants from blast-induced secondary debris:
   - Multi-hit Glass Penetration (MHGP) model to predict glass penetration injury
   - Blunt unfilmed glass (BLUUFG) and blunt filmed glass (BLUFIG) models for blunt trauma head injury from glass
   - Building Injury Calculator and Databases (BICADS) model to predict all types of injuries to building occupants based primarily on large injury databases collected after bombings
   - Vulnerability Assessment and Vulnerability Option (VAPO) vulnerability assessment code that includes all of the above injury prediction methods
4. DTRA is involved with ongoing test series to determine blast loads and potential injuries in multi-room structures from thermobaric explosives.

Current Work:
Current DTRA work is a Human Injury Gap Study (HIGS) by an A&AS team of Northrup Grumman and Protection Engineering Consultants (PEC). The HIGS will:

- Summarize existing models and research in blast injury area
- Focus on injuries from high explosives and, to a lesser extent, injuries from chemical-biological and nuclear radiation weapons
- Identify gaps in basic science and modeling of human injury from blast, particularly those critical to DTRA perspectives of physical security from terrorism and weaponeering
- Include gaps in basic science, injury prediction models, and injury modeling within larger integrated models for physical security and weaponeering
- Recommend research plan for DTRA to fill gaps that are critical from DTRA's perspective by developing blast injury data and enhanced prediction models
- Define integration needed to keep DTRA involved with other HI injury research and development organizations.

Planned Work:
Planned work is to be determined after conclusion of HIGS later this year

Applied Research Associates (ARA) Blast Injury Research Briefing Summary:

Ms. Lee Ann Young, Applied Research Associates (ARA)

Over the past eight years, Applied Research Associates (ARA) has been involved in explosion bio-effects research and development for the Technical Support Working Group, the Defense Threat Reduction Agency, the Army Research Laboratory, Aberdeen Test Center, and the Defense Advanced Research Projects Agency. The following paragraphs summarize and highlight a few recent, current, and near-term explosion injury research activities and offer suggestions for remaining technology gaps impeding solution to pressing counter-terrorism, materiel design, physical security, and collateral damage concerns.

In 2004 and 2005, ARA chaired four meetings of the Blast Injury Testing Conference sponsored by the Technical Support Working Group (TSWG) in which Government, academic, and industry medical, physics, and engineering personnel met to identify technology gaps and requirements for better preventing, predicting, mitigating, and treating the bio-effects of blast. The gap analysis performed during these meetings was used to outline a program for addressing underlying science and technology shortfalls such as the absence of high-rate materials properties, injury criteria, and validated physical and numerical models.

Currently, ARA is leading a test program through TSWG to evaluate the effectiveness of tactical ballistic gear in a blast environment. During this study, improvised explosive device (IED) (simulated pipe bomb) blast tests are being performed on vests and helmets currently worn by first responders using anthropomorphic test devices (ATDs), porcine specimens, and cadavers. In the context of this research, we have confirmed that Level IV ballistic protective gear provides additional protection in the blast environment and face shields provide significant additional protection over helmets.

As TSWG's Lethality Subject Matter Expert, Ms. Lee Ann Young (ARA) is overseeing TSWG's Clinical Specification of Next Generation Body Armor (NGBA) program, under which SimQuest, LLC (SQ) has combined the Army's Joint Theater Trauma Registry (JTTR), the Marines' Combat Trauma Registry (CTR), and the Armed Forces Medical Examiner's Tracking System mortality database into a single system that can be queried using both standard analytical techniques and SQ's Surface Wound Mapping software for visualizing wound patterns. Although input and coding of epidemiological data is ongoing, the NGBA system has already been beta tested and preliminary analytical reports have been completed. Additionally, the feasibility of using CIDNE numbers to link epidemiological and event forensics data in the Combined Explosives Cell (CEXCE) reports has been demonstrated, and by the end of August 2006 SQ computers with the NGBA software will be located at both the National Ground Intelligence Center (owner of CEXCE reports) and Natick Soldier Center. By offering the event to forensics data connection, the NGBA program is expected to continue into Phase 2, where the scope will be expanded to provide a Comprehensive Injury Data Analysis Platform (CIDAP) for design of vehicles and protective equipment.

In a related effort, the Office of Naval Research has contracted with ARA, SQ, and the University of Virginia to serve as the core team of a bio-effects consortium that will again draw together Government, academic, and industry blast injury and blast physics experts, this time to

identify current gaps in understanding, research, and technology related to injuries to occupants of IED-exposed vehicles. This group will develop the survivability-based performance requirements and test standards for the Joint Light Tactical Vehicle. In a related program, ONR intends to support reviewing epidemiological data and event forensics data not only to illuminate the type of injuries occurring to the vehicle occupants, but also to enable identification of injuries that are preventable with proper design, the source of those injuries, and the most high-return areas of vehicle redesign to minimize morbidity and mortality.

In light of the highlighted programs herein as well as other programs in which ARA has been involved in the recent past, some critical technology gaps are: 1) epidemiological data (this is being addressed through CIDAP, but continues to require support); 2) injury criteria for repeated blast exposures (head *and* thorax); 3) high-rate material properties; 4) animal-to-human scaling factors; 5) *validated* physical, numerical, and engineering models; 6) brain injury prevention and treatments (this is being addressed by DARPA); 7) injury criteria and engineering models for blast-induced structural debris penetration and blunt trauma; 8) whole body acceleration injury criteria; and 9) synergistic blast/ballistic effects.

END OF PROCEEDINGS